

DOCUMENT RESUME

ED 151 183

SE 023 951

TITLE Developmental Approaches to the Teaching of Science and Mathematics. Case Studies Report.

INSTITUTION Southern Regional Education Board, Atlanta, Ga. Inst. for Higher Educational Opportunity.

PUB DATE Apr 76

NOTE 72p.; Not available in hard copy due to numerous small print throughout document

EDRS PRICE MF-\$0.83 Plus Postage. HC Not Available from EDRS.

DESCRIPTORS Biology; Case Studies (Education); Chemistry; *College Science; *Educational Innovation; Educational Research; *Higher Education; *Instruction; *Mathematics Education; *Science Education; Teaching

ABSTRACT

This report describes three innovative instructional programs which have demonstrated that carefully designed non-traditional instruction can have a positive influence upon student performance. The programs are the mathematics program of the Clearwater Campus of St. Petersburg Junior College, the biology program of Miles College, and the chemistry program of the University of Southern Mississippi. (SL)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

Developmental Approaches to the Teaching of Science and Mathematics

Case Studies Report

ED151183

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

SCOPE OF INTEREST NOTICE

The ERIC Facility has assigned this document for processing to:

In our judgment, this document is also of interest to the clearinghouse noted to the right. Indexing should reflect their special points of view.

SE 023 951

Southern Regional Education Board

DEVELOPMENTAL APPROACHES TO THE
TEACHING OF SCIENCE AND MATHEMATICS

Case Studies Report

April 1976

SOUTHERN REGIONAL EDUCATION BOARD
Institute for Higher Educational Opportunity
130 Sixth Street
Atlanta, Georgia 30313

Table of Contents

	<u>Page</u>
Foreword	iii
Introduction	1
Features and Components of an Effective Developmental Program Ralph L. Pruitt	3
Developmental Mathematics Ralph L. Pruitt	10
Developmental Science Alfred Young	23
Miles College Audio Tutorial Program in Biology Jacqueline J. Irvine	31
St. Petersburg Junior College, Clearwater Campus Systems Approach to the Teaching of Mathematics Jacqueline J. Irvine	45
University of Southern Mississippi A Developmental Program in Chemistry Samuel E. Cary	57

Foreword

Our efforts to provide equality of educational opportunity requires increased concern for student retention. Traditional instruction alone may not meet individualized educational needs of underprepared students and may present barriers to maximum development.

As a result, institutions have introduced a variety of innovative instructional programs, some of which have demonstrated that carefully designed non-traditional instruction can have a positive influence upon student performance. This report describes three such programs; the mathematics program of the Clearwater campus of St. Petersburg Junior College, the biology program of Miles College and the chemistry program of the University of Southern Mississippi.

It is hoped that the report will be informative and useful to institutions which seek to enhance educational opportunities for students in need of special assistance.

Appreciation is expressed to the presidents and faculties of the institutions aforementioned for their cooperation and support.

Winfred L. Godwin, President
Southern Regional Education Board

INTRODUCTION

The necessity for institutions of higher education to address themselves to the needs of the educationally disadvantaged has become obvious during the last few years. "Open door" admission policies, quota systems, liberal veterans' benefits, an expanding urban-suburban population, and a general deterioration of core curricula in and depersonalization of inner city schools has led to large factions of entering college classes being composed of ill-prepared students.

Kotnik summarizes the characteristics of these students.

Poor mathematics background . . . Their math deficiencies include the inability to handle fractions, decimals and, obviously, algebra.

No high school chemistry course or a poor science course taken in an inner city school . . . Even the extraordinary, experienced teacher who remains in the inner-city school more often than not becomes frustrated, then finally disillusioned. Hence, poor courses result.

A tendency for this type of student to pursue short-term goals rather than long-range planning with deferred gratifications.

A severe lack of self-confidence.

The underprepared student has bad study habits and an inability to concentrate.

A necessity for outside employment.

A repulsion by apparently cold instructors who convey a highly impersonal subject matter.

Boredom with repetitious drills on routine, seemingly irrelevant topics.

A tendency to emphasize memorization of "formulas" while avoiding mathematical solutions to problems.

The students are extremely weak in English. Their reading ability is very poor; their writing ability worse.

The needs of these students are seldom adequately met despite a proliferation of "special" programs designed for this purpose. Instead of capitalizing on students' strengths, many of these programs, it is felt, force students to "do something fast"; many of the programs lack careful design and are token in scope. The fact of the matter is that many colleges were not prepared to allocate resources to provide the necessary instructional and counseling support in addition to implementing a positive approach to learning. The obvious outcome is that black students have a dropout rate of 29% (Alexander Astin, 1975) and represent only 7.4% of the college population (New York Times, May 18, 1975).

The situation, however, is brightened by the development of some programs for minorities characterized by good diagnosis, careful management, innovative instructional techniques, and dedicated and well-trained staff. A careful case study of these often under-publicized programs will serve as a guide to other institutions as they search for demonstrated techniques and methods designed to retain minority students.

No single procedure, program, or technique can be considered as the best one for all situations. Every institution must determine what is most suitable for the type of students it enrolls and give consideration to various budgetary, staff, and facility constraints that exist at the given institutions.

The Institute for Higher Educational Opportunity acknowledges the contribution of Dr. Ralph L. Pruitt, dean of the division of special studies, Cleveland State University, Cleveland, Ohio, and Dr. Alfred Young, director of the doctor of arts program in chemistry, Atlanta University. These consultants participated

in a planning session for this project, helped to develop the criteria by which these sites were selected, and outlined for this publication the components of effective developmental mathematics and science programs.

This document recognizes that programs designed to meet the academic needs of students with varying degrees of secondary school preparation are not necessarily called developmental programs. The prototypes described in this document generally adhere to some of the characteristics described by Dr. Pruitt.

FEATURES AND COMPONENTS OF AN EFFECTIVE DEVELOPMENTAL PROGRAM

An effective developmental program should have at least four features or phases, and seven components.

The features or phases should include:

1. Identification
2. Diagnosis
3. Prescription
4. Evaluation

Identifying student difficulties can be determined from test and course assignment performances. A student who fails the first test of a course and claims something was wrong with the test or the grading process immediately confirms that a problem exists.

Diagnosis might well begin by a conference with the student on the identified problem to provide the student and his advisor with a more objective understanding of the student's difficulty or weakness.

Establishing a clearer understanding of the particular weakness of a student

leads to a prescription of activities and procedures to be followed. Such a prescription might include securing an individual tutor, re-doing the exercises missed on the test or the assignment, studying programmed materials, or using films, filmstrips, and tape recordings on the topic.

Upon the conclusion of prescribed instructional or attitudinal activities, the results of the prescription must be determined by evaluation. Evaluation measures the extent to which the prescription and other procedures used have helped toward decreasing or eliminating a weakness in a student. The evaluation process requires the use of data collected during every phase of the developmental process. It should reveal the attitudinal changes that hopefully have occurred in students with respect to their self-perception, their perceptions of the world at large, and perceptions toward education, study, and work. This calls for regularly scheduled attitudinal testing. A comparison of grades and cumulative grade point averages each term with those students not participating in the program is valuable. Standardized testing will show student progress in the cognitive understanding necessary for positive achievement.

Evaluation should be designed to show what impact the program has had on the larger university or college in the local community. Finally, it should afford data about the impact of such procedures on students during their college and post-college years.

Some components of successful developmental program efforts are generally considered to be:

1. Institutional Commitment
2. Faculty
3. Instruction
4. Counseling

5. Self-Concept Development
6. Program Image
7. A Separate Program

It should be noted that a successful program can exist without all seven of these components.

Administrative leadership at a college or university which strongly supports and commits a fair share of its funding and facilities to a developmental program can very well be the most crucial factor for the program's success. A developmental program requires more money per student than does a program for regular students. Many programs have been funded primarily with federal or other grant dollars rather than from college or university funds. The present trend by the federal government to curtail funding for Special Services to the Disadvantaged mandates that colleges and universities commit funds and facilities to such services and programs if they are to be viable sources of help to students needing such services.

The chief administrative officer should define the extent of the institution's commitment to the developmental program and make it known to faculty that they are expected to become involved and to participate actively in developmental programs.

The institutional commitment is also manifested in the extent to which developmental program students are provided with adequate financial aid and work study. The majority of the students in such programs have need for total financial aid.

Faculty members who are experienced, capable, and who honestly and sincerely care about other human beings and their needs should be encouraged to

perform the instructional responsibilities in a developmental effort and they should be adequately rewarded for doing so. Often the most inexperienced faculty, if any faculty at all, are involved in developmental programs. Many programs have to settle for instructional services by graduate and upper level undergraduate students. These individuals in general do a good job but their continued use tends to lessen the chance for the program to work itself into the mainstream of the institution's educational thrust. Whatever the makeup of the faculty personnel, it should also consist of persons who reveal to the students that they have high expectations of them and will hold them to respectable levels of performances.

Department chairmen should recommend faculty to the director of the developmental program and these individuals should meet standard departmental qualifications.

A commitment must be made to qualify education in preliminary and introductory courses, and it must come in the form of faculty talent utilization and recognition. Instructors for such courses should be chosen according to their interest in the work and recognition must be given for productivity in that endeavor, not in standard scholarly pursuits.

The instruction in a developmental program cannot follow any one method. A variety of methods -- both traditional and innovative -- must be employed. Individual and group tutoring services are most desirable in the instructional effort. Tutoring services should afford supportive teaching which is used when students have made mistakes in tests or course assignments. Tutoring services should provide crisis teaching when students show anxiety over failure or slowness to learn. Tutoring services also should make available diagnostic teaching which should begin when observation shows that students are in great

difficulty and are showing no progress. In order for tutoring services to be most effective, it is necessary that a plan be followed which provides regular interaction on progress and learning and involves the students, their advisors and counselors, and their instructors.

From observations, research reports, and experience, the most effective counseling is the result of a "team" effort. Each team has a professional counselor as its key member. Student advisors or peer counselors should be assigned to a team for routine and more frequent counseling contacts with a group of developmental students assigned to the given team. Peer counselors are a distinct asset to the counseling effort, for very often developmental students can and will relate to them more freely than to the professional counselor.

Counseling efforts should make available specialized counseling on admissions procedures, financial aid requirements and possibilities, exit counseling when students must be dismissed for a period, and readmission counseling when such students have met the requirements necessary for them to be considered for readmission.

The general lack of self-confidence in the typical developmental student requires that every developmental program emphasize the innate worth of the individual student and his development of a positive self-concept. The male student is more likely to lack self-confidence than the female student, and the male commuter student falls into this category more so than any other developmental student. Evidence of this was reported by Roueche and Kirk (1973). Roueche and Kirk also reported on programs which seek to develop three behaviors in their students: the ability to recognize and appreciate their own unique talents and abilities; the ability to establish meaningful and lasting

relationships; and the ability to perceive themselves as worthy and valuable human beings. They propose the use of small group discussions and individual interactions on a one-to-one basis to help students see that they are not alone in their weaknesses and difficulties. Plans which offer students opportunities to show that they can succeed should be promoted and executed in a good developmental studies effort.

The image that a program enjoys in an educational enterprise often enhances the success of its efforts. In general, data show that developmental programs attain admirable success with students who in most cases would otherwise become total failures. Institutions which take on the role of publicizing the data and which direct the registrar's office to report to high school counselors and teachers about students from their schools would greatly enhance the image of the program. Too often all responsibility in this connection is left with the program itself. If such is the case, the program administrators must see to it that chief institutional officials and the admissions and registrar's offices are made aware of such data. Means of publicizing should be sought; public dissemination of retention, achievement, and attitudes development data is essential for the establishment of a good program image.

Institutions of higher education in general show some ambivalence in recognizing developmental programs as separate programs and the need for supporting such programs as separate entities when budgetary and priority constraints are rigid as they now are. Separate programs under the aegis of one administrative structure, with cooperative effort from the various departments and divisions, provide for more cohesion and a better articulation of program goals and accomplishments. Some minority groups whose students could not persist without these programs are reluctant to accept the fact that they can best serve

the needs of students in separate programs.

If it were possible in the immediate future for colleges and universities to permeate their efforts for the education of all students with the special kind of care that developmental students require, the aforementioned positions of reluctance would be acceptable. But the needs of such students for teachers who care about them, for counselors who extend themselves to help them, and for academic instruction designed specifically for them make it quite clear that developmental programs should be separate.

Astin and her colleagues (1972), as the result of a recent survey, recommend as components of a successful program:

1. Institutional Commitment
2. Well-Defined Recruitment and Admissions Practices
3. Orientation and Diagnosis
4. Curriculum Development
5. Counseling and Tutoring
6. Financial Assistance and Work-Study Experience
7. Extra Curricular Activities
8. Faculty and Other Staff
9. Evaluation and Follow-Up

DEVELOPMENTAL MATH

Ralph L. Pruitt, Dean
Division of Special Studies
Cleveland State University
Cleveland, Ohio

A recent issue of the Chronicle of Higher Education pointed out the fact that college entrance examination scores have declined significantly over the last ten years. Various reasons have been hypothesized for this decline, but evidence is not sufficient to isolate the reasons why new college enrollees are deficient in basic mathematical understandings. While the responsibility for this situation cannot and should not be attributed entirely to the teaching of mathematics, institutions of higher learning need to recognize the problem and seek ways to alleviate this continuous waste of human potential which could have undesirable effects on the future development of our society.

Research completed by Blanton (1964) on experiments in developmental mathematics for freshmen at Abraham Baldwin College in Tifton, Georgia shows that educationally disadvantaged or minority students often feel inadequate, inferior and uncertain in mathematics courses. Similar evidence can be found throughout the literature. The point here is that the problem is universal in our nation. What should be faced is what we must do to improve basic mathematical understanding so that the fears, the trauma, and the anxiety of students will be recognized and that they will be directed toward efficient productivity as citizens in our society.

MATHEMATICAL WEAKNESS OBSERVED AMONG DEVELOPMENTAL STUDIES

Students with mathematical deficiencies can easily be identified, for most of them score in the lowest third on tests of mathematical ability. They show glaring weakness in their understanding of basic concepts and skills regarding whole numbers, fractions, decimals, percents, verbal problems, elementary notions of algebra, geometry, and trigonometry.

Time and space will not permit an exhaustive analysis of the types of mathematical difficulties which students have.

Verbal problems pose significant difficulty for many students and especially the disadvantaged and culturally different student. Examination of published material (Butler and Wren, 1965) on problem-solving in arithmetic indicates that many of the difficulties can be attributed to one or more of the following, but not necessarily in the order named

1. Computation
2. Lack of reasoning ability
3. Poor procedure or complete absence of systematic attack
4. Difficulty in selecting the process to be used
5. Failure to comprehend the meaning of the problem
6. Inefficient reading habits
7. Vocabulary difficulties
8. Short attention span
9. Inability to select essential data
10. Carelessness in transcribing
11. Poor eyesight and other physical defects
12. Lack of interest
13. Guessing because of desire for a quick answer

Some methods which have been developed for teaching problem solving are:

1. The restatement method in which students are asked to restate each problem in their own words as a means of clarifying the problem;
2. The analysis method in which effort is made to have students systematically analyze the problem by requiring them to go through a sequence of steps.
 - a. What is required?
 - b. What is given?
 - c. What operations are to be used?
 - d. Estimate the answer.
 - e. Solve the problem.
 - f. Check the answer by an estimate.
3. The method of analogies in which students are given simple oral problems similar to, but shorter than, the more difficult written problem.
4. The method of dependencies in which students are taught to recognize and focus on fundamental dependence relations existing among elements or sets of elements in the problem under consideration.
5. The graphic method in which students are taught to use some graphic or diagrammatic scheme to help them identify the elements of the problem and formulate an explicit statement of their relations to each other.

No single method can be considered as the best method for teaching verbal problems. Good teachers usually make use of a combination of methods.

Many of the difficulties students experience in verbal problems in arithmetic exist in algebra.

It is important to realize that a thorough analysis of errors by students on a battery of mathematical tests or on a set of assignments will reveal many of

the difficulties they encounter.

SOME INNOVATIVE INSTRUCTIONAL TECHNIQUES OF DEVELOPMENTAL MATHEMATICS PROGRAMS

It has been my privilege to conduct two surveys in the last five years of the innovative methods used in the teaching of mathematics in colleges and universities in Ohio. A survey indicates that the methods employed in higher education institutions in Ohio are quite similar to those used throughout the country. Institutions using the same name for a particular method in no way meant that the same procedures were being followed. The second survey, completed in the spring of 1975, did show, however, that more institutions were using innovative methods in the teaching of mathematics than was the case in the first survey, conducted in 1972.

The 1972 survey included sixteen selected colleges in Ohio. The respondents indicated that their innovations were limited to the lower level and elementary calculus courses in mathematics. The general format of the innovations followed the module or mini-course concept. Students had access to various study and learning aids as well as help from tutors and instructors. Immediate or quick reinforcement after testing was available and testing schedules and achievement requirements were flexible. A certain amount of responsibility, however, had to be manifested by the student. As determined by both students and instructors, the innovative methods used seemed to have improved the amount and quality of mathematics learned by students. A final finding in the 1972 study was that innovative programs require special effort and preparation to attain worthwhile benefits.

The purpose of the 1975 study was to look at the impact of innovative teaching of mathematics in all Ohio colleges and universities to gain some

perspective of the following:

1. The number of Ohio colleges and universities engaged in such efforts;
2. The structure and procedures they employed as contrasted with what was found in the earlier study;
3. The effectiveness of such methods as determined by survey results;
4. The recommendations of users of innovative methods to others concerned about improved teaching and learning in lower college level mathematics.

A survey questionnaire was sent to the eighty institutions in Ohio including four-year colleges and universities, two-year community and junior colleges, and technical institutes. Thirty-three responses were received, six of which indicated no innovative programs were in operation but, in two of these cases, programs were being planned.

The questionnaire sought the following information:

1. The type of innovative method(s) in use in freshman and sophomore mathematics;
2. A description of how the method(s) were used;
3. At least three primary objectives in using the method(s);
4. The number of years the method(s) had been in use;
5. An evaluation of any methods used for at least one quarter or semester;
6. An evaluation of the performance of students who participated in such programs as compared to those who did not participate;
7. The recommendations that institutions using such methods would make to other institutions considering their use.

Institutions reported such innovative methods as:

Modules
Mini-Courses
Individual Study
Honors Courses
Examination
Clusters

TV Courses
Laboratory Courses
Tutorial Program
Seminar Courses
Continued Progress
Computer Courses

perspective of the following:

1. The number of Ohio colleges and universities engaged in such efforts;
2. The structure and procedures they employed as contrasted with what was found in the earlier study;
3. The effectiveness of such methods as determined by survey results;
4. The recommendations of users of innovative methods to others concerned about improved teaching and learning in lower college level mathematics.

A survey questionnaire was sent to the eighty institutions in Ohio including four-year colleges and universities, two-year community and junior colleges, and technical institutes. Thirty-three responses were received, six of which indicated no innovative programs were in operation but, in two of these cases, programs were being planned.

The questionnaire sought the following information:

1. The type of innovative method(s) in use in freshman and sophomore mathematics;
2. A description of how the method(s) were used;
3. At least three primary objectives in using the method(s);
4. The number of years the method(s) had been in use;
5. An evaluation of any methods used for at least one quarter or semester;
6. An evaluation of the performance of students who participated in such programs as compared to those who did not participate;
7. The recommendations that institutions using such methods would make to other institutions considering their use.

Institutions reported such innovative methods as:

Modules
Mini-Courses
Individual Study
Honors Courses
Examination
Clusters

TV Courses
Laboratory Courses
Tutorial Program
Seminar Courses
Continued Progress
Computer Courses

A total of 50 cases of the above methods were in use. Eleven of the institutions were using more than one method. Individual study and modules were used in most cases reported. Nine programs had been in use for a year, five for two years, and 36 for three or more years. No program was evaluated as unsatisfactory, 22 considered their results satisfactory, and five claimed excellent results. Higher test grades and higher performance levels seemed to have been achieved by students.

Procedures varied in the use of each method in different institutions, but there was a common effort to have students understand smaller amounts of content on a self-paced basis. Flexibility in testing and tutorial services were available, as was the case in 1972. Several programs made use of variations of the methods within a selected method.

Primary objectives were generally aimed at higher levels of understanding, individual study, and performance. They also sought to provide opportunities for in-depth study of special topics that were of need or interest to students.

The recommendations presented were emphatic in stating the need for:

- (1) enthusiastic, dedicated and capable teachers;
- (2) sufficient time to plan, prepare, and develop appropriate course materials and procedures;
- (3) sufficient supportive staff, funds, and facilities; and
- (4) keeping the system of testing and grading as simple as possible.

These innovative methods of teaching mathematics in Ohio's institutions seemed to have definite impact on positive results and could have the same effect in any developmental mathematics program for any institution of higher education.

THE CURRICULUM FOR DEVELOPMENTAL MATHEMATICS

Effective results in developmental mathematics teaching can be achieved by using seminars, workshops, and laboratories. Development of understanding and learning lends itself to the inductive, problem-solving approach as the major thrust. Programmed instruction materials can be of help.

Flexibility in scheduling and in time required to complete modules or mini-courses with less emphasis on grades (at least in the beginning) is conducive to more satisfactory performance levels on the part of students.

Students who perform below the tenth grade level in mathematics on reputable standardized tests should be placed in a developmental laboratory or workshop. Materials should be supplemented by conscientious tutoring in the basic skills of arithmetic, algebra, and elementary geometry. Multi-media devices of both audio and visual types should be available for use with the students. Students' content deficiencies and learning styles should be diagnosed so that individualized prescriptions of curricula and developmental material may be used. Materials should emphasize problem-solving in series of drills and exercises to supplement and solidify ideas and concepts.

A curriculum framework could embrace a specific short-term objective or a set of objectives to be attained along with the regular college or university curriculum in mathematics. If the short-term approach is followed, the curriculum would consist primarily of special courses and programs designed to prepare students for the freshman mathematics courses. For the more extended objectives, special non-credit developmental courses or seminars would be scheduled both in addition to and in place of regular courses. A more extended set of objectives would make it necessary to emphasize and supplement the content of regular freshman college courses. Many text materials are available for use in

developmental mathematics courses.

A good example of a first course in college mathematics with emphasis on self-paced development in arithmetic is suggested by Willerding (1975). She presents the course in four modules.

Module One

1. The decimal system of numeration
2. Addition and subtraction of whole numbers
3. Multiplication and division of whole numbers

Module Two

4. Factors and factoring
5. Rational numbers and fractions
6. Decimals

Module Three

7. Percent
8. Measurement
9. Geometric figures and their measures

Module Four

10. The integers and their operations
11. Equations and inequalities
12. Squares, square roots, and similar triangles

Hart (1975) has written a good text on a developmental algebra course which provides for substantial foundation in manipulative algebra, including acquaintance with the function concept, and some experience with the fundamentals of analytic geometry. The text includes:

1. Basic topics

2. Linear equations and inequalities in one variable
3. Square roots, factoring, and fractions
4. Introduction to functions and graphs
5. Radicals and rational exponents
6. Operations on sets and inequalities
7. Quadratic equations and inequalities in one variable
8. Certain sequences and series
9. Quadratic equations in two variables
10. Logarithms
11. Determinants and systems of linear equations

BUDGETARY CONSIDERATIONS

Very little of the literature makes specific recommendations regarding expenditures per student served. This is understandable since necessarily there would be wide variations in such cost estimates. The literature emphasizes strongly, however, that adequate funding is necessary for the success of developmental programs.

Each institution, as it commits itself to a developmental program, would have to determine a per student expenditure or secure cost estimates from institutions which have such programs in operation. It must be expected, however, that the per student expenditure for a developmental student will exceed the expenditure for students who do not need developmental services.

The following tests and their publishers are recommended instruments for the assessment of mathematical ability:

DIFFERENTIAL APTITUDE TESTS - Form L and M (Numerical Ability Section)

The Psychological Corporation
304 E. 45th Street,
New York, N. Y. 10017

AMERICAN SCHOOL ACHIEVEMENT TESTS (Mathematics)

DETROIT GENERAL APTITUDES EXAMINATION (Mathematics Skills)

METROPOLITAN ACHIEVEMENT TESTS (Adv. Battery, Form AM and KM)

The Bobbs-Merrill Company, Inc.
4300 W. 62nd Street
Indianapolis, Indiana

STANFORD ACHIEVEMENT TEST (Intermediate Level - Form KM)

Arithmetic Reasoning
Arithmetic Computation
Average Arithmetic

Harcourt Brace Javonovich Inc.
757 Third Avenue
New York, N. Y. 10017

SEQUENTIAL TESTS OF EDUCATIONAL PROGRESS (STEP) - Form 2A Math Section

Bureau of Educational Measurements
Kansas State Teachers College
Emporia, Kansas 66801

IOWA TEST OF BASIC SKILLS (ITBS) Form I

IOWA ALGEBRA APTITUDE TEST

The Bureau of Educational Research and Service
C-6 East Hall
The University of Iowa
Iowa City, Iowa 52240

CALIFORNIA ACHIEVEMENT TESTS, Math Computational Skills, Forms I and II

California Test Bureau, A Division of McGraw Hill Book Co.
Del Monte Research Park
Monterey, California 93940

SCHOOL AND COLLEGE ABILITY TESTS (Math Section)

SEQUENTIAL TESTS OF EDUCATIONAL PROGRESS (Math Section)

Cooperative Tests and Services
Educational Testing Service
Princeton, New Jersey 08540

MEASURING MATHEMATICAL COMPUTATIONAL SKILLS (Forms A-E)

Houghton Mifflin Company
Educational Division
110 Tremont Street
Boston, Mass. 02107

WISCONSIN CONTEMPORARY TEST OF MATHEMATICS

Personnel Press, Inc.
20 Nassau St.
Princeton, N. J. 08540

STS TESTS OF ACADEMIC PROGRESS (Math Section)

Scholastic Testing Service, Inc.
480 Meyer Road
Bensenville, Illinois 60106

SRA ACHIEVEMENT SERIES (Math)

Science Research Associates, Inc.
259 East Erie Street
Chicago, Illinois 60611

WIDE RANGE ACHIEVEMENT TEST (Math Section - Level I and II)

Guidance Associates
1526 Gilpin Avenue
Wilmington, Delaware

References

- Astin, H.S. et al. Higher Education of the Disadvantaged Student. Washington, D.C.: Human Services Press, 1972.
- Blanton, F.L. "The Results of Two Experiments in Remedial Mathematics for College Freshmen at Abraham Baldwin College", Research Report Number 64-2. Tifton, Ga.: Abraham Baldwin College Office of Institutional Research, January 1964.
- Butler, C.H. and F.L. Wren. The Teaching of Secondary Mathematics. Fourth Edition. New York: McGraw-Hill Book Co., Inc. 1964, 303-304.
- Hart, W.L. Algebra, A. College Course. Boston: Prindle, Weber, and Schmidt, 1975.
- Kotniz, L.J. "Teaching Science to the Disadvantaged Student in an Urban Community College". Journal of Chemical Education, 1973. 50,467-468.
- Roueche, J.E., and R.W. Kirk. Catching Up: Remedial Education. San Francisco: Jossey-Bass, Inc., 1973.
- Willerding, M.F. A First Course in College Mathematics. Boston: Prindle, Weber, and Schmidt, Inc., 1975.

DEVELOPMENTAL SCIENCE

Alfred Young, Director
Doctor of Arts Program in Chemistry
Atlanta University
Atlanta, Georgia

THE EDUCATIONAL NEEDS OF STUDENTS IN DEVELOPMENTAL SCIENCE

In 1971, the Education Commission of the States undertook a project, the National Assessment of Educational Progress, whose main purpose is to measure change in what children and young adults knew and could do. Science, among other subjects, was assessed in 1969-70 and again in 1972-73. The nature of these reports reflects the performance of blacks at different levels of education with performance of blacks in educational subjects outlined.

The major results of the 1970 study in science regarding the performance of blacks were as follows:

Blacks performed between 12 percent and 16 percent below the national average at the four age levels: 9, 13, 17, and young adults (26-35). When results were partially adjusted ("balanced") for disproportionate representation of blacks on the variables of size of community, level of parental education, sex and region, the reduced difference between black and national performance was between -7 and -10 percent at the four age levels. Blacks performed best on those science exercises largely dependent upon daily experience and common knowledge, and worst on those which involved a detached research attitude toward the objectives and phenomena of science.

Although many efforts have been made to improve and make use of innovative methods of teaching in the various academic disciplines, in comparison, little has been done to address the need to improve instruction in science for nonscience majors.

As knowledge in all areas has increased, there has been a tendency for each academic department to become more intensive in its preparatory courses so that students majoring in a given discipline will have a firmer foundation for success in that field of study. This is particularly true of the life and physical sciences. Facts suggest that such technical courses do not fit the needs of many students in other fields. These students do not need to be trained in science but need to be knowledgeable about scientific concepts in order to be able to function and participate in a highly technological society. (Puri, 1970)

Today's college science teacher is often confronted with nonscience majors who approach courses in science with apprehension. This apprehension is often increased by students' preconceived notions that what is happening around them either cannot be understood or is too complex to be appreciated. As a result of such attitudes, general or physical science courses are looked upon by these students as requirements outside of their areas of specialization and, if given the option, many of them would avoid taking the course. (Labianca, 1975)

Thus, the college science teacher is faced with the challenge of proving to nonscience majors that science is a part of their daily lives and that science is not isolated and understandable only by a select few.

Moreover, the point must be emphasized that the ability to think logically and to communicate information (qualitatively and quantitatively) is also an integral part of the study of other academic disciplines. In effect, one of the goals of the college science teacher is that of convincing the non-science major of the significance of Warren Weaver's comment in Science and Imagination (1967).

. . . science is not an arrogant dictator in the whole arena of life but rather a democratic companion of philosophy, of art, of religion, and of other valid alternatives approaches to reality.

SOME INNOVATIVE TECHNIQUES FOR DEVELOPMENTAL SCIENCE PROGRAMS

Education has been one of the prime stimuli for development of sophisticated technology in our society but, ironically, it has made less of technology than industry and the armed forces. In fact, education has proved to be one source of strong resistance to the use of technology for its own purposes. However, stimulated by the growing shortage of faculty members, the increase in students and problems of cost, and encouragement from some of the major foundations, the situation is shifting rapidly today. (Horn and Morisseau, 1965)

Paul Mort (1964) has stated, in describing what is commonly called the "Mort Gap," that early studies indicated that change in the American schools comes through a glaringly slow process and follows a predictable pattern. Furthermore, between insight into a need and the introduction of an acceptable way of meeting the need, there is typically a lapse of a half century.

Skinner (1961) makes the point that education is perhaps the most significant branch of scientific technology. Education affects the life of us all. Concerned educators can no longer allow the exigencies of a practical situation to suppress the tremendous improvements which are in reach. The practical situation must be changed.

Programmed instruction is the kind of learning experience in which a "program" takes the place of a tutor and leads the student through a set of specified behaviors designed and sequenced to make it more probable that he will behave in a given desired way in the future. In other words, he will learn what the program is designed to teach him. Sometimes the program is housed in a "teaching machine" or in a "programmed text". The content of the material is the important thing about programmed instruction. (Deterline, 1962)

Most teachers agree that if learning is to occur, a rather rigid, though friendly, control of the student is necessary. A major problem has been the question of how to exercise this control. What programmed instruction can control by itself is insufficient. The knowledge to be imparted must be presented orderly in a manner which is understandable to the student. This really is the point. This knowledge is usually presented in a linear or an intrinsic, or branching, program. (Day, 1963)

A linear program consist of a series of expository statements, in which the student is interrogated as he fills in the blanks. The student is lead in a direct linear manner from the initial to the concluding statement. A branching, or intrinsic, program consists of a series of pairs of exposition-question sets. Each of the several direct questions which is used in such a program is intrinsic with the exposition that precedes the question. (Young, 1963)

Both types have their particular areas of use and their vigorous proponents. Both linear and intrinsic techniques can be used. Many of the best recently-produced programs include both features, although one or the other will be dominant.

In a properly prepared program, students are not challenged beyond their ability as often is the case in traditional instruction. If a student cannot think of a word or words to fill in the blank, he may look at the answer in the margin and then proceed. Students quickly recognize that they are only cheating themselves when they look at the answer without first attempting their own. Since no grade is given, there is little temptation to use the program incorrectly.

When the student cannot supply the correct answer, the author of the program has failed. A program is, quite literally, a test in which the student supplies the answers. If the student gives an answer that differs from the author of the program, it is the programmer who is wrong, not the student. The student is no longer under the control of the program writer and, in such an event, the program must be revised to be as "error free" as possible (usually a 5 to 10 percent error rate is regarded as acceptable). (Fry, 1963)

Programmed instruction may not be the panacea for teaching courses at all levels but it has proven to be as effective as the conventional method of instruction in teaching skills and specified bodies of knowledge in several disciplines. For the immediate future, it appears that programmed instruction should be used to supplement regular courses rather than to replace them entirely.

THE AUDIO-TUTORIAL SYSTEM

Many educators who have faced a classroom full of students have been perplexed with the problem of presenting their subject matter at a level which stimulates and challenges each student in the class. Almost without exception there is considerable range of ability, motivation to learn, goals to achieve, background preparation, and other factors which affect total learning. In an attempt to remedy some of these differences in students, Dr. S. N. Postlethwait, professor of biology at Purdue University, prepared some special audio tapes designed to assist students who had poor backgrounds in science. He invited students to listen to the tapes prior to attending the week's lectures. From this meager beginning in 1961, the evolution of the audio-tutorial system of teaching science was set in motion.

Students at all age levels vary greatly in their cognitive development

regarding specific subject areas; individual differences in learning style and rate therefore require some mechanism for individualization of instruction. Learning must be done by the learner. Only if students had the same background of experiences and were capable of learning at the same rate could a fixed style and rate of instruction accommodate the needs of all students. The audio-tutorial system is an attempt to individualize instruction by enabling the students to proceed independently in a study program and control the rate and intensity of study at each step. Learning events include a great range of experiences, such as reading from the text or manual, doing an experiment, collecting and analyzing, manipulating apparatus, watching a time-lapse movie, listening to brief discussions, and any other activity that will assist the student in accomplishing stated behavioral objectives.

A PERSONALIZED SYSTEM OF INSTRUCTION

The past several years have witnessed many instructional innovations, some representing temporary fads and others having a more substantial and lasting impact on college teaching. Among the latter is the personalized system of instruction (PSI), known also as individualized instruction and the Keller Method. (Fernald, 1974) It is important to note, that the meaning of the term PSI varies because instructors teaching PSI courses do not always employ all the procedures and those that are adopted are sometimes modified. For this reason, reported successes or failures of PSI do not necessarily reflect the method as a whole.

Many schools are using the Keller method; few if any, are using the same procedures with the same emphasis. This reporter has observed a very successful modified Keller method PSI employed at Spelman College for non-majors in chemistry. Emphasis at Spelman is on individualized learning, self-

paced instruction and mastery-oriented learning -- a highly recommended teaching method for nonscience majors.

COOPERATIVE GENERAL SCIENCE PROJECT

Clark College is the only college in this area, or perhaps in this nation, which has developed courses that are strictly structured for nonscience majors. This nationally and internationally recognized program (CGSP) came about as a result of a 1965 grant from the United States Office of Education.

Under CGSP, students must take one semester each of physical science and biological science. All nonscience majors in the Atlanta University Center enroll in these classes. Teaching is interdisciplinary and materials used are produced by CGSP rather than by commercial publishers of textbooks and lab manuals.

The following units are recommended for a two-semester course:

Astronomy
Chemistry
Geology
Meteorology
Physics

Evolution
Heredity and Genetics
Ecology
Health
Drugs and Drug Misuse

For a one-semester course the following topics are recommended:

Astronomy
Chemistry
Meteorology

Ecology
Health
Drug and Drug Misuse

NOTES:

1. The content of a general science course should be relevant and meaningful.
2. Emphasis should be placed on an understanding of the fundamental principles of sciences, using inductive and deductive reasoning, and on procedures and methods in science rather than memorization.

3. If the two-semester general science course is one each of physical science and biological science the sequence in which they are offered should not present a problem.

References

- Day, Jesse H. "Intrinsic Programs." Journals of Chemical Education. 1963, 50, 1, 14-15.
- Deterline, William A. An Introduction to Programmed Instruction. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1962.
- Fernald, Peter S., et al. Introduction to Psychology: Using Tests in Teaching. 3rd ed. Boston: Houghton Mifflin Company, 1974.
- Fry, Edward B. Teaching Machines and Programmed Instruction: An Introduction. New York: McGraw-Hill Book Company, 1963.
- Horn, Francis and James Morisseau. "Facilities and Learning: An Overview of Development." Higher Education: Some New Developments. Ed. Samuel Baskin. New York: McGraw-Hill Book Company, 1965.
- Labianca, Dominick A., "Science for the Nonscience Major Through Interdisciplinary Study: The Interrelation of Science and Art." Science Education, 1975, 59:2, 187-190.
- Mort, Paul. "Research and Theory." Innovation in Education. Ed. Matthew B. Miles. New York: Bureau of Publications, Teachers College, Columbia University, 1964.
- National Assessment of Educational Progress. Report 7: 1969-70 Science, p. 1.
- Puri, O. P., et al. Teacher's Guide to Concepts and Experiments in Physical Science. Reading, Massachusetts: Addison-Wesley Publishing Co., 1970.
- Skinner, B. F. The Technology of Teaching. New York: Appleton-Century-Crofts, Inc., 1961.
- Weaver, Warren, Science and Imagination, New York: Basic Books, 1967.
- Young, Jay. "Programmed Instruction". Journal of Chemical Education, 1963, 50, 1, 11-13.

AUDIO-TUTORIAL PROGRAM IN BIOLOGY

Miles College
Fairfield, Alabama

by
Jacqueline J. Irvine
Program Associate
Institute for Higher Educational Opportunity
Southern Regional Education Board

INTRODUCTION

Miles College is a four-year, accredited, liberal arts college enrolling some 1300 predominantly black students. It is located in Fairfield, Alabama, adjoining Birmingham. The college is supported by and affiliated with the Christian Methodist Episcopal Church.

Miles has never been restrictive in its admissions policies and thinks of itself as an "open door" college. Welcoming applicants who are high school graduates or have equivalent certificates, Miles does not use test scores as a basis for rejecting candidates for admission, but seeks to make a careful evaluation of each individual's potential, based on the entire record. The general philosophy of admissions is to admit all serious and determined students who come, even though they may seem somewhat academically weak, and then assist students in every way to succeed in their college work.

THE STUDENTS

The students are mostly from the state of Alabama. The socio-economic level of the students is best characterized by the fact that nearly 80 percent of the students are on some type of financial aid. The ACT test is administered to students and the majority score in the lower percentiles.

A longitudinal study of students admitted in August 1972 showed that of the 151 freshmen admitted, 91 or 60 percent are still in school. Of those 91 students still enrolled, 54 had reading scores of eighth grade or below at admission time, and 18 had reading scores of seventh grade or below. Considering the ACT tests, of the 91 students remaining, 21 had ACT composite scores of one to seven, in the bottom 1 percent of the national sample. Not one of the 91 students had an ACT composite of eighteen or better, however, 21 of these 91 students have had straight honor records. (Munro, 1974)

THE AUDIO-TUTORIAL BIOLOGY PROGRAM

In 1970, Bernice Coar Cobb attended a seminar at Purdue University which focused on a new approach to the teaching of biology. S. N. Postlethwait designed Purdue's program in 1961 as an attempt to make some adjustment for the diversity of backgrounds of students in a freshman botany course. Impressed with the program, Ms. Cobb returned to Purdue in 1971 as a graduate teaching assistant.

Upon returning to Miles in 1974, Ms. Cobb formally started the program for nonscience majors in the fall of 1974. The program grew out of a need for individual instruction and Ms. Cobb's perception that students were bored with the traditional methods. During the planning process, support was solicited from the faculty through seminars in which the audio-tutorial approach was presented and discussed.

The audio-tutorial program at Miles has six main parts:

The instructor (on tape)

Printed materials - graphs, charts, study guides, textbooks

Tangibles - live frogs, flowers, preserved worms, seeds, microscope slides, etc.

Projectuals - slides, film strips, movies

An instructor in the lab to answer questions

The learner

The audio-tutorial approach in biology uses a combination of films, slides, tape recordings, demonstrations, and short reading assignments. The course is divided into a sequence of instructional units called minicourses or modules. Each module is self-contained and students are able to work independently and at their own pace. The units include a statement of purpose and instructional objectives.

Some advantages of this minicourse concept are:

Pacing - The use of a self-instructional minicourse provides an opportunity for individual pacing at two levels -- within the minicourse and within the traditional "course" designation. Students can be totally independent in their rate of study for a minicourse if they so desire. With few exceptions, it is not necessary to meet specific schedules or progress at a specific rate. Emphasis is placed on acquisition of the information rather than on the time or rate of accomplishing the task. This is an especially important advantage for open colleges where students with little academic training are attempting to do college work. The magnitude of a conventional load of course work may be overwhelming and a student who fails to complete it in the prescribed time may become so humiliated and frustrated by the experience that his status is worse at the end than at the beginning.

Evaluation - Because of the compact and repeatable nature of a minicourse, the effectiveness of the learning strategy can be critically examined and evaluated. Components of a study program can be analyzed and eliminated, enlarged upon, reorganized or resequenced to provide the most efficient and effective study activities.

Flexibility - Sequencing of subject matter can be more flexible than with the conventional course. Not all students should begin at the same level or with the same topics. It is feasible then to allow students to begin by studying their primary interest and to spread their base of knowledge as their interest grows.

Multi-courses - Subject matter can be adjusted to individual needs. A student can take those minicourses particularly adapted to his own needs. The number of overlapping minicourses in an individualized curriculum will vary depending on the requirements or needs of the students.

Success orientation - The concept of learning for mastery can be satisfactorily implemented through the use of minicourses. No student need fail any minicourse since the size of the unit and the use of specifically stated and measurable objectives permit adjustment in study procedures related to individual needs. Failures can be pinpointed to specific subject matter (behavioral objectives) and remedied. The student can spend whatever time is necessary for him to achieve the minimum requirement. Since grades are not based on competition, students are free to help each other.

Team teaching - Minicourses provide an opportunity for using the very best teachers and subject matter experts to produce the instructional programs. A "pool" of these instructional programs provides a modified team-teaching approach with the potential for selecting the team of teachers from a great range of experts.

Increase personal contact - The use of minicourses provides an excellent opportunity for personal contact between students and staff. Instructors, free of the repetitive activities of dispensing information, can deal with student problems on an individual basis. Teachers have time to give guidance to students who wish to go into greater depth, and to elaborate important and interesting points for those students who may desire it.

Frequent revision - Minicourse programs can undergo frequent revisions without a major overhaul of the entire biological curriculum. Each revision of a given topic can be based on the need for change, whether to update content or to improve the program's effectiveness.

Increase reinforcement - Since each minicourse is a complete unit and is tested at the end of the study, the student will receive immediate reinforcement or correction before progressing to the next unit of study. This reinforcement may be of considerable consequence for both attitude and "readiness" for subsequent study. A lack of feedback to the student can often result in frustration and, in some cases, a false sense of security.

Multi-approaches - Many principles can be approached in a great variety of ways. With the minicourse concept it is possible to provide alternate programs for certain subject matter and to permit students to select the program which is best suited to his/her own particular interest, background and capacity.

Greater adaptation to varied teaching strategies - Minicourses provide a greater opportunity to adapt the teaching strategy to the subject matter being taught. Conventional courses commonly use only lectures and a lab; all subject matter is forced into this format. By using minicourses, one can employ the teaching strategy best suited to the nature of the content.

Multi-sensory - Minicourses make it possible to use instructional strategies which involve all of the sensory stimuli. One can structure a program involving sound, touch, taste, and sight. It seems logical that a correlation must exist between the extent and variety of stimuli and the amount of learning that occurs.

Multi-use - Once a minicourse has been well established, its content clearly identified, and its program known to be effective, the minicourse may be useful in a great variety of courses.

Lower cost - If minicourses can be used in this great variety of contexts and offer the advantages listed above, the cost of the total educational program for a student should be decreased. (Postlethwait, 1972)

The emphasis in this course is on the use of media, audio and visual, as an instructional tool. This approach seems appropriate since research at Miles indicate that only 3 percent of the students are formal thinkers and many have difficulty with abstract concepts.

The audio-tutorial lab, with 21 carrels, is open from 8:00 a.m. until 4:00 p.m., Monday through Friday. Students can come in at their convenience and spend as much time as is necessary to master the materials. An instructor is available at all times to assist students on an individual basis. In addition, students frequently help each other. The responsibility for learning rests with the student.

The open lab approach is befitting an institution like Miles where students frequently live at home, maintain off-campus employment, and require some flexibility in their schedules. To further accommodate students, tapes are recorded for home use and review booths are available for students to re-examine past units.

The lab contains many bio-constructs, some made by students, some commercially-made, which help students to learn by examination of tangible items. Live plants, models, diagrams, charts, and equipment for experiments are available.

The course, serving some 180-200 students per year, is composed of traditional (25 percent) and non-traditional techniques (75 percent). It is

not remedial or compensatory and a high degree of academic excellence is required.

The biology course is divided into four structural parts

Independent study sessions (ISS)

General assembly sessions (GAS)

Quiz sessions (QS)

Small assembly sessions (SAS)

The independent study session is based on the premise that learning must be done by the learner, and the emphasis is placed on learning rather than the length of time involved. The independent study session room contains the tapes, instructional materials, diagrams, charts, and other instructional aids. The most important feature of this component is the opportunity to bring different approaches to bear on a single topic in a coordinated series of learning events. The general assembly session is useful for large group sessions. It is the feature which is similar to conventionally structured courses. The quiz session meets once a week for a written review of the minicourse. The small assembly session is for group discussions, examinations, and article summaries.

Peer tutoring is available through a performance instructor -- a student who formally helps another student. The student who tutors serves one hour per week after successfully passing the minicourse or module with at least a mastery of 90 percent. Students receive a grade of A, B, or C. There are generally no D or F grades. The grade of C reflects a general level of knowledge of all materials presented in the course with a mastery at least 90 percent of the objectives on every minicourse. Students receiving an A or B can accomplish the following objectives:

Read and summarize scientific articles;

Generalize from data, synthesize, transfer information, predict, integrate, formulate hypotheses, compare and contrast;

Use knowledge to help others reach similar level of mastery.

Students who do not master the objectives return to the audio-tutorial lab the next semester to complete the course or are assigned a special project. This approach reinforces a positive self-concept in students. Students receive only positive feedback and, consequently, exhibit positive self-images as a result of their achievement.

The audio-tutorial system of learning has some important features not commonly found in a conventionally-taught course.

1. Repetition There is little question that many objectives require repetition for their achievement. However, repetition ought to be engaged in intelligently and adapted to the individual needs of a particular student. In a large course the teacher cannot possibly adjust to individual student need. Only the student can determine intelligently how much repetition is necessary.
2. Concentration Most classrooms are not organized to permit students to concentrate during their study. Students are distracted by one another, and disassociated events. The audio-tutorial system permits the student to isolate himself from the surrounding environment.
3. Association In a study of plant science the major objective is to learn about plants. It makes sense, therefore, that a study of plants should be conducted where plants are available for observation. The audio-tutorial system provides an opportunity for the student to have an object available at the time he reads about it, does experiments, etc.
4. Appropriate sized units of subject matter The amount of subject matter that people grasp in a given amount of time varies considerably. Programmers have demonstrated that most people can learn almost anything if it is broken into small enough units and the student can take time to become informed about each unit before proceeding to the next. The audio-tutorial system allows the student to proceed at his own pace and to break the subject matter into units commensurate with his ability.

5. Adapt the nature of the communication vehicle to the nature of the objective It is logical that no single vehicle achieves the full spectrum of objectives for a complex subject. The student's experiences should not be confined to one particular film, audio tape, textbook, or lecture. In cases where the development of a procedural skill is necessary, there is no substitute for the student doing this procedure himself. A properly structured course, therefore, would carefully define objectives and would use the medium best adapted to the nature of the objective.
6. The use of multi-media Individuals differ in their responsiveness to different kinds of communication devices. Some people learn well through reading, some can learn best by literally handling specimens and performing experiments. The audio-tutorial system provides an opportunity for subject matter to be covered in a variety of ways with the student exploiting the medium which communicates most directly and effectively for him.
7. The integration of learning activities and situations It stands to reason that if learning events are to be complementary and to have some relationship, they should be brought into close proximity and properly sequenced. The conventional structuring of a lecture, for example, a lecture on Monday, lab experiments on Wednesday, recitation on Friday and textbook study on Sunday, does not take this into consideration. The audio-tutorial system permits the student to bring all of these learning experiences into an integrated sequence so that each learning event may enhance or complement the adjacent ones and thus result in a 'synergistic' effect. (Postlethwait, 1972)

EVALUATION

Students are given a series of pre- and post-tests for diagnostic purposes. These tests include the life science achievement examinations, personality inventories, Piagetian pencil and paper test and the Biology Attitude Examination.

The division of natural science includes the departments of mathematics, biology, chemistry, and physics. The biology department has five full time instructors, who average six years of experience in higher education. Three of the instructors teach six freshman biology classes. Three of these classes are taught by the audio-tutorial method (the experimental group) and the other three are taught via the conventional method (the control group).

A study was conducted and the following hypotheses were tested.

1. Students taught by the audio-tutorial method have a higher level of achievement in biology than do students who are taught by the conventional method.
2. Students taught by the audio-tutorial method have a more positive attitude toward the sciences than do students taught by the conventional method.
3. Students taught by the audio-tutorial method have a higher level of cognitive thinking and development than do students taught by the conventional method.

The results of this investigation indicate that these assumptions are valid, and are further indications of the effectiveness of the audio-tutorial methodology. Another indicator of the effectiveness of this program is the increase in the number of biology majors since the program began.

The guidance and counseling program is an integral part of the educational process of all students enrolled at Miles College. The program is particularly important for freshmen who enroll at Miles under the "open door" admission policy. The counseling program is a major component of the freshman studies program in the overall effort to provide individualized educational services to beginning students.

The counseling center staff use both group processes and individual counseling in helping students adjust to college. The purposes of the staff are to help each student to know himself as an individual and as a member of society, to make the most of his strengths and recognize his limitations, to collect pertinent information about his needs and potentials and relate them to his college work and career choices, and to work through social, moral, and spiritual problems common to young people. The staff tries to help each student select wise educational and vocational goals, to attain a realistic self-concept, and to help develop control over the decision-making process.

The counseling services at Miles are integrated into the academic disciplines. Students who are enrolled in the audio-tutorial biology (as well as other courses) and are having difficulty meet with counselors regularly to define the source of the problem and to identify some strategies and plans which will enable them to experience success. This institutional approach and the individualized attention received in the laboratory have proven helpful to students. (Miles College Bulletin, 1974)

INSTITUTIONAL COMMITMENT

Miles College's commitment to the program is evidenced by the administration's total financial support. Although the audio-tutorial method initially cost approximately \$100 per student (50 percent more than the conventional lecture method), the administration provided adequate support and plans to continue this funding of the program in the future. Presently, the program costs are similar to the conventional method because hardware for the laboratory does not have to be purchased each semester.

The faculty has also supported the program which is evidenced by the fact that several faculty members have implemented the approach in other courses. Faculty attitudes have been positive and any criticism given has been constructive.

PROGRAM PROBLEMS

- Most of the materials in the laboratory (which were constructed on the campus to keep the cost) low are too portable and subjects the lab to a certain amount of vandalism and theft of property.
- After twelve years of conventional instruction, students sometimes find it difficult to adjust to a non-traditional method of instruction.
- Some students who are not mature enough sometimes take advantage of the flexibility of this approach. (Since its inception, the course has been revised several times to provide more structure.)

PROGRAM FUTURE

Future plans for this program all point in the direction of expansion. The department of natural sciences plans to supplement many of their courses, through the senior level, with the audio-tutorial method.

STUDENTS' REACTIONS TO THE PROGRAM

A survey was taken by the staff to assess students attitudes about the course. The results of the survey are listed below:

	YES	NO
1. Do you feel the audio-tutorial center is more interesting than the regular instructional class?	25	8
2. Do you feel that all classes should be set up like the audio-tutorial center?	13	22
3. As an overall opinion do you find the center motivating?	21	11
4. Has the center benefited you in any way as a student?	32	2
5. If you could change something about the center, what would you change?		

The responses most often received were:

- The center should be open for longer hours
- There should be more security for tapes and recorders.
- The test-taking procedure needs revision.
- There is need for more scientific experiments and more lectures by instructors.

Generally, students find the audio-tutorial method fosters a sense of independence and is stimulating and motivating.

AN ADMINISTRATOR'S REACTION

Dean Alandus C. Johnson considers the audio-tutorial program most appropriate for Miles' experimental and innovative spirit. In using the approach, the college has an additional alternative to meet the learning needs of some of the students. He encourages the usage of the audio-tutorial method when appropriate and enthusiastically recommends it for other institutions as an alternative teaching strategy.

APPENDIX A

Sequence of Life Science - Audio-tutorial Units

1. Microscope
2. Unit of Life
3. Cellular Ulstrastructure
4. Complementarity of Structure & Function
5. DNA
6. Protein Synthesis
7. Cellular Respiration
8. Mitosis
9. Meiosis
10. Genetics
11. Human Reproduction
12. Puberty-Menstrual Cycle
13. Birth Control
14. Pregnancy
15. Drugs and You
16. Ecosystem
17. Human Population
18. Kidney Structures and Function
19. Excretion
20. Pulmonary and Heart Disease
21. Plant Growth and Development

References

Monro, John, "The College as an Agent for Social Change". (Speech delivered at Emory University, Atlanta, Georgia, 1974.)

Postlethwait, S. N., The Audio-Tutorial Approach to Learning. Minneapolis: Burgess Publishing Co., 1972.

SYSTEMS APPROACH TO TEACHING MATHEMATICS

St. Petersburg Jr. College
Clearwater Campus

by

Jacqueline J. Irvine
Program Associate
Institute for Higher Educational Opportunity
Southern Regional Education Board

INTRODUCTION

St. Petersburg Jr. College, Clearwater Campus, was opened in 1965 to provide for the rapidly expanding population of upper Pinellas County, Florida. The college has public school status, and is under the direct control of its own Board of Trustees.

High school graduates and individuals with equivalent certificates are eligible for admission. Students who are not high school graduates are eligible for admission on an individual waiver basis. Admission by waiver is obtainable by mature students, early admission students, credit bank students and non-degree students. There is a 6 percent minority enrollment, out of a student body of 3,300.

Mature students are applicants who are at least 19 years of age and have not graduated from high school, but satisfy all other requirements. Early admission students enter St. Petersburg Junior College after the eleventh grade of high school and have eleven units in a high school where fifteen units are required for graduation. In addition, a grade point average of 3.0 on a 4.0 scale is required. Credit bank students earn college credit while enrolled in high school. A non-degree student is a student who does not desire to enroll

as a degree-seeking student but would like to earn credit for certification or other purposes.

THE STUDENTS

The students come mostly from lower middle class families and graduate from high school in the upper half of their class. Recently there has been an increase in the number of older students and veterans. Many of the students have a common characteristic, however, that of a weak mathematics background.

THE PROGRAM

In January of 1966, Mr. Robert Alwin developed an innovative method for teaching algebra to eight of his students. Motivated out of a need to do something about the high failure and the high withdrawal rate in mathematics, he started developing programmed materials for a mathematics laboratory. Presently, the laboratory serves over 700 students each session and is open from 8:00 a.m. to 2:00 p.m. five days a week, and from 6:30 to 10:00 p.m. Monday through Thursday. The laboratory is supervised by three full time instructors and seven part time instructors. Since its inception, the program has served over 5,000 students.

During the planning process, the first task seemed obvious. The mathematics textbooks being used were not appropriate. Together with a reading specialist, Mr. Alwin and associates, Mr. Hackworth and Mr. Howland, wrote completely new materials with reading levels and vocabulary suitable for the needs of the students. By 1969 the arduous task was completed and the materials were published in two textbooks by Prentice-Hall, Inc. Two years later, two additional textbooks were completed and published. The 4 textbooks are entitled Algebra-Programmed, by Alwin, Hackworth and Howland. The first two textbooks were written by Alwin and Howland. Hackworth wrote books three and four.

The programmed materials in the mathematics lab have been developed for four different courses. Students are placed in the math course deemed appropriate by the guidance counselors who evaluate mathematical ability by an assessment of the high school transcript and the Florida Twelfth Grade Test.

DS-70--Directed Studies Mathematics is a review of basic mathematics and algebraic skills and concepts. It is designed for students who have no prior knowledge of algebra.

MS-110 and MS-111--General Education Mathematics is a two semester sequence course designed for students with at least one year of high school algebra. The topics include mathematical logic, set symbolism and terminology, elementary algebra, probability, statistics, matrices and application.

MS-169--Intermediate Algebra is designed for students with two years of high school algebra, or one year of algebra and one year of plane geometry. The understanding and use of techniques of algebraic manipulation are the major objectives.

Occasionally an individual student will register for College Algebra, Statistics, or Trigonometry on an individual (independent) basis for credit in the laboratory. This is done to overcome scheduling difficulties for students from time to time.

An individualized study of mathematics makes allowances for differences in students' backgrounds. Each student goes through the material at his own rate of comprehension. Those able to complete the program more quickly are unhindered by normal class progress. Others who find it impossible to keep pace with a lecture class can master the materials at a slower rate. There is no class presentation made by an instructor in this system. Mastering of the skills and concepts rather than attendance in class for some artificial time frame is important.

There are four basic learning modes in the primary learning activities component -- two individualized study modes, the group learning mode, and the

lecture mode. Each mode is directed toward achieving the same set of objectives, but the individual student has a choice of modes to fit his own personal instructional needs and learning style. The four learning modes are designed so a student may change modes if he feels his progress can be improved.

By far the most popular modes of instruction are the individualized study offerings. Ninety-five percent of the beginning algebra students now enroll in individualized study programs for the simple reason that these programs have been far more effective in terms of pupil success than group instruction by the lecture method. This success has been proven in both the class in which the student is presently enrolled, and the following mathematics course.

Each course has a programmed textbook and a placement test. On the first day of class, students take the placement test to determine what chapter in the course is an appropriate starting point. If a student answers all items correctly on the test, he has passed the course and enrolls in the next mathematics course in the sequence. Students are not required to repeat materials they have already mastered. If the student experiences difficulty, he knows exactly what chapter or chapters in the textbook to study. The pre- and post-testing in the algebra course is probably the most important facet of the program.

There are no structured time frames for completion of work. It is possible for one student to test out of a course in a single class period where it may take another student two or more semesters to complete the course requirements.

The other individualized study mode also centers its work around a textbook. The book is written for student readers rather than their teachers and features detailed explanations, numerous examples, and frequent problems interspersed with the reading. The programmed and reading texts follow the same sequence of topics

and the explanations are very similar. Students who do not need the constant reinforcement of programmed material are usually placed in this second individualized study mode.

The group learning mode currently attracts only five percent of the beginning algebra students. The small group discussion mode is in its earliest phase of development. The learning teams consist of approximately four students who organize for achievement of the course objectives. Successful discussion groups form naturally from students who are maintaining the same pace in the individualized instruction. These groups continue to use the same programmed or reading texts but expand their study to include discussion group activities. Many times these small discussion groups are managed by the instructor.

The lecture method mode is the last learning mode of the system. Seven years ago almost all beginning algebra students enrolled in the lecture course, but the high failure and dropout rates encouraged students to look for an alternative and very few students now request the lecture method. At this time there are no lecture classes in either Elementary or Intermediate Algebra.

Regardless of which basic learning mode is chosen, each student has available two types of supplemental learning materials. When a particular skill is not understood the student can listen to an audio-cassette presentation or view a sound film which teaches that skill. There are seventy-three audio-cassette lessons for the two algebra courses, each with its own worksheet; there are twenty-eight sound films. Both the audio-cassettes and the sound films are available to the student on an individual basis in the mathematics classrooms and in the Learning Resource Center in the library. As it was with the two textbooks, these supplementary materials were specifically designed for this integrated instructional package. In addition, help is available by

qualified instructors daily and two evenings per week.

Video tapes of lectures are available in the Learning Resource Center for students in all four of the programmed courses. The students can repeat the lectures as many times as necessary before taking a test. The system has a four channel potential and all film is produced by the library staff of the college.

The system has a two camera input, special effects generator, recorder, and console. The initial investment cost approximately \$11,000 and maintenance of the system is minimal.

Unlike other tape systems, such as the dual access system, the amount of human contact between the student and the library staff is great, and the system is highly individualistic and personal.

The last phase of the learning activities component is preparation for the mastery tests. Two specific aids are available to the students for this purpose. Sample mastery tests with answers are included in both the programmed and reading texts. Also, a video-tape discussion of each mastery test is available in the campus library.

Students who are unsuccessful on a mastery test begin the recycling process with an interview with the instructor. In that interview, the student and the instructor try to analyze specific difficulties shown by the test with the intention of formulating learning activities that will overcome the deficiencies. The most common prescriptions are: (1) re-doing some of the work in the primary learning activities component, (2) specially developed slide-cassette presentations, and (3) direct tutoring by the instructor.

The college requires six hours of mathematics credit for graduation.

All mathematics courses earn academic credit. Directed Studies, DS-70 does not count for mathematics credit, but as an elective credit toward graduation.

Each student sets his/her own speed through the material. The important factor is not speed, but constant progress. Grades are determined by the amount of work completed. Every student is expected to master whatever material is completed and demonstrate this mastery by success in the testing program. No student can fail a test; failures are not accepted. If a student has difficulty with a test, then re-study and re-testing are required.

Directed Studies Mathematics DS-70 - Finishing the two books in this course earns a grade of "S" (satisfactory), which carries three hours of institutional elective credit. Finishing at least two chapters of book 2 earns a grade of "X" (audit) which is changed to an "S" when the student later completes the remaining chapters. Finishing less than two chapters of book 2 means a grade of "W" (withdrawal). Any student who receives a "W" may re-enroll in the course, starting where he left off, and complete the course with an "S".

General Education Mathematics MS-110 and 111 - The grade for these courses is determined by the number of units successfully completed. Eight units completed earns the grade of "A"; 7 units a "B"; 6 units a "C"; 4-5 units an "I" (incomplete); and 0-3 units a "W". The course ends when the student finishes the work. The grade schedule is used to assign grades at the end of the semester. However, the student may finish before or after the end of the semester. Students who complete the course early are under no obligation to continue attending class. Students who have not completed the course at the end of the semester may continue on, without starting over, in the next session.

Intermediate Algebra, MS-169 - The grade for this course is determined by

the number of units successfully completed. Completion of the two books for the course earns a grade of "C". Successful completion of both book tests earns a "B" and completing a short word problem unit earns an "A". Students who do not finish the second book receive an "I". Students who do not finish at least the first chapter of book 4 will receive a "W". To pass a test, a minimum score of 80% is required.

THE FACULTY

The mathematics department is part of the division of science and mathematics at St. Petersburg Junior College, and is headed by a director who has administrative responsibility for the division along with the assistant director of mathematics and an assistant director of science. The mathematics department has sixteen full-time faculty and all but three use the systems approach. Three faculty members who use the systems approach direct the lab. The faculty who use the systems approach meet the same criteria as the other faculty who use the traditional approach, and work in the program by choice.

EVALUATION

An evaluation of the effectiveness of the program can best be illustrated by an analysis of the failure and withdrawal rate.

During the fall semester, 750 enrolled in the mathematics course taught by the three instructors who maintain the Mathematics Laboratory. Of this number less than 10 percent withdrew and there were no failures. Prior to the implementation of the systems approach the withdrawal rate was 30 percent and the failure rate 40 percent.

Students attitudes with respect to mathematics seem to change in a positive

direction as the student progresses through the Algebra programs. Since no time parameter is set for the individual student, the normal pressures he generally encounters are not present. Two years ago a follow-up study pointed out two important aspects of the Algebra courses taken under laboratory conditions. For the Intermediate Algebra course it was concluded that there were far fewer withdrawals in the laboratory approach than in the old lecture type classrooms. The study also showed that the laboratory students were more successful in the course which generally follows Intermediate Algebra, College Algebra.

INSTITUTIONAL COMMITMENT

There has been tremendous support by the administration, faculty and students. The support is evidenced by the institution's total financial funding of this program and the fact that the approach was adopted by 13 of the 16 math faculty members.

The costs are minimal, except for the initial investment of audio tapes and tape players. Perhaps the greatest expense was the cost of time it took the instructor to plan, design and implement the approach.

PROGRAM PROBLEMS

- There is a need for an adequate screening test to determine at what course level students need to enroll. Counselors, using the results of the Florida Twelfth Grade Test and high school records, often place students in an inappropriate course. Students spend weeks encountering unnecessary difficulty because they were placed in a course which is much too advanced.

- Often unmotivated students do not attend the lab regularly and budget their study time inappropriately. Presently, any student whose progress is

inhibited by poor attendance is dropped after a conference with the instructor.

FUTURE PROGRAM PLANS

Future program plans include:

- A revision of the four programmed algebra books;
- Writing of a College Algebra book to fit the model of the other four books; and
- Expansion of the laboratory to accommodate students not enrolled in the four courses. This is to include special modular units in Science and Business courses.

AN ADMINISTRATOR'S REACTION

Johnny Ruth Clark, associate dean of Academic Affairs, feels that the systems approach has served as catalyst by interesting other instructors in the personalized approach to instruction. The students in the program are closer in personal relationships than students in the traditional program, and many are experiencing their first success in mathematics. Students who have been in the program are making progress, as well as or better than other students.

Attention needs to be given to more thorough diagnostic techniques, counseling and career guidance. Dr. Clarke hopes that the program will be expanded in order to accommodate more students. The program has a great deal of faculty support but pockets of real resistance do exist.

APPENDIX A

DS 70 Course Outline

1. Sets
2. Algebra of the Counting Numbers
3. Algebra of the Integers
4. Algebra of the Rational Numbers
5. Graphing and Algebraic Solutions for Linear Equations with Two Variables
6. Algebraic Polynomials, Factoring, and Fractions
7. Solving Fractional and Quadratic Equations with Rational Solutions
8. Solving Quadratic Equations with Irrational Solutions

MS 110 Course Outline

1. Real Number System
2. Sets and Logic
3. Metric System
4. Algebra I
5. Consumer Mathematics
6. History of the Real Numbers
7. Geometry
8. Numeration

MS 111 Course Outline

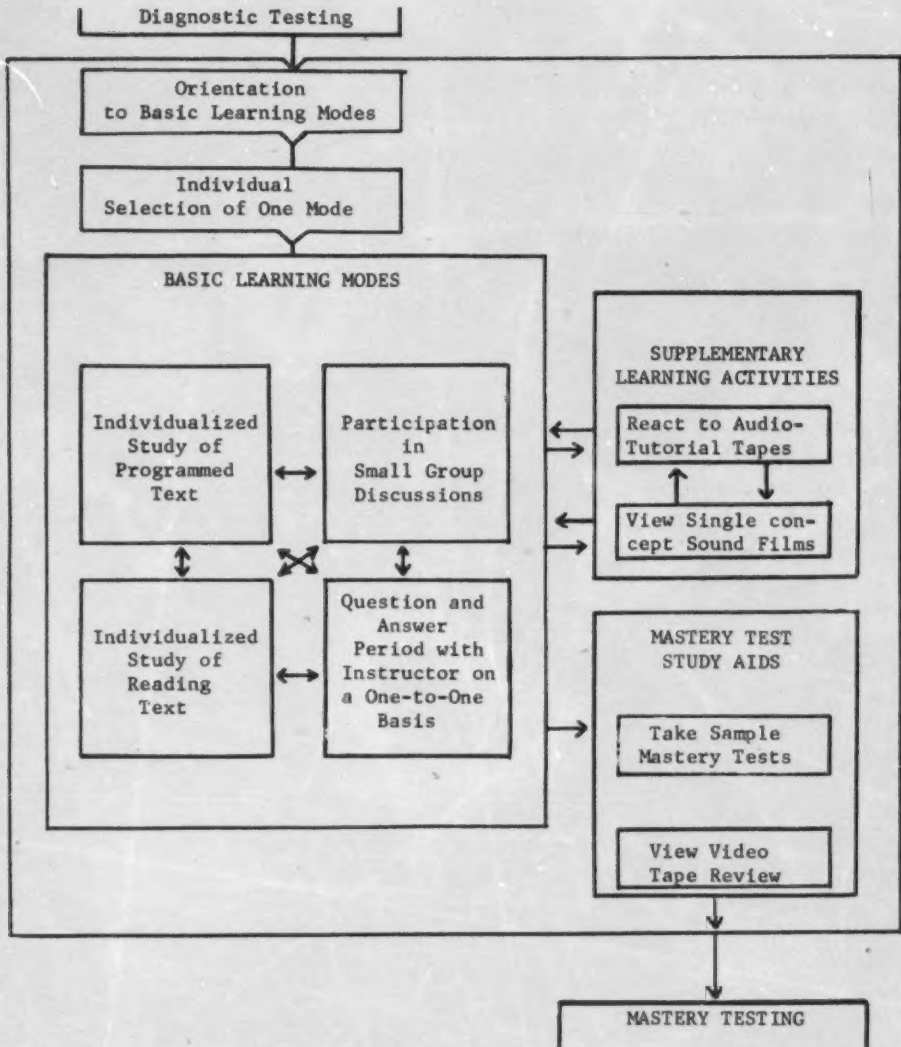
1. Probability
2. Statistics
3. Tables and Graphs
4. Geometric Measures
5. Indirect Measuring
6. Algebra II
7. Computers: History and Concepts
8. Linear Programming

MS 169 Course Outline

1. System of the Rational Numbers
2. System of the Real Numbers
3. System of the Complex Numbers
4. Sets, Relations, and Functions
5. Inequalities
6. Absolute Values
7. Graphing First and Second Degree Equations and Inequalities
8. Exponents and Radicals
9. Factoring (Special Cases)
10. Logarithms

APPENDIX B

THE PRIMARY LEARNING ACTIVITIES COMPONENT



A DEVELOPMENTAL PROGRAM IN CHEMISTRY

The University of Southern Mississippi
Hattiesburg, Mississippi

by
Samuel E. Cary
Associate Director for Programs
Institute for Higher Educational Opportunity
Southern Regional Education Board

THE UNIVERSITY AND STUDENTS

The University of Southern Mississippi is a state supported institution located in the southeastern section of the state. The institution received its university status officially in February, 1962. The name has changed for the third time since the institution was established by the legislature in 1910 as Mississippi Normal College with the express purpose of training teachers for the rural schools of Mississippi. The university structure is composed of three schools and five colleges at the undergraduate level, the Graduate School, the Graduate School of Social Work, and the division of Extension and Public Service.

Requirements for admission to the university include the high school transcript and the American College Test (ACT) score. Applicants who are twenty years of age and older and are not high school graduates are considered for admission on the basis of their scores on the General Education Development Test (GED). Exceptions to the stated requirements for admission must be approved by the dean of admissions. The university requires a composite score of 15 on the ACT, however, the freshman class does include a minimal number of students whose scores are below 15.

The current enrollment of students at the university includes approximately

7800 undergraduates and 1800 graduate students. The freshman class numbers 1800 students of whom 13.1 percent are black Americans who also comprise approximately 9.4 percent of the total student body. The majority of the students are graduates of small rural high schools throughout the southern section of the state. Economically, 10 percent of the students represent the upper middle class, 60 percent are middle class, and 30 percent come from low income backgrounds. Fifty-three percent of the black American students enrolled have low income backgrounds.

A significant number of students admitted to the university each fall are graduates of very small and poorly staffed and equipped high schools. These students arrive with meager academic background in advanced mathematics and science. Even today, general mathematics and elementary science are the only programs that are available in some schools, and these are not always taught by teachers prepared in either or both fields. According to officials of the university, many of the rural communities have not yet developed the economic resources necessary to promote improved high school programs.

Despite the handicaps that have reduced the quality and quantity of educational opportunities, the motivational levels of the students admitted to the university each year have been relatively high and have been a major factor in the success of the students.

THE PROGRAM

As related by Dr. John H. Bedenbaugh, chairman of the Chemistry Department, the difficulties experienced by the freshman students in the General Chemistry course and the high number of failures which was increasing yearly convinced the faculty and the students that something should be done to alleviate these conditions. Further, upon recognizing the inadequacies of the students' high

school preparation in the sciences, the students and faculty were in agreement that the General Chemistry course was much too rigorous. Although the faculty believed it was a legitimate course for freshman students, they agreed that it was probably geared to the students who were planning to major in chemistry and definitely did not consider the students who either took no high school chemistry or had done poorly not only in their high school chemistry course but also in other science courses. A two-track system was instituted, the "upper" track for science majors and the "lower" track for non-science majors.

In 1970, Dr. J. Emory Howell was appointed Director of General Chemistry and given the specific responsibility to develop innovative approaches for teaching General Chemistry to science and non-science majors and a program that would be compatible with the interests and abilities of the freshman students enrolled at the university. The new program would require the students to learn that body of chemistry needed for their success in their chosen major fields.

Dr. Howell did not elect to present and to implement an entirely new program immediately. The first approach was to seek ways to maximize teacher-student interaction and individualize instruction in the large cross sections that existed, for the lack of such interaction and help obviously was responsible, at least partially, for the low morale and the high failure rate of the students.

Individualized instruction was maximized by using a programmed supplementary text and by introducing some audio-tutorial units which the students used in an open laboratory, as no learning center existed at the time. Teacher-student interaction was maximized by the use of "help" sessions held in otherwise empty classrooms. This proved ineffective because with several students present at the same time the sessions often became mini-lectures. Performance objectives,

stated in behavioral terms, were utilized and examination questions were based upon these objectives.

Dr. Howell and the faculty were not satisfied with the two-track system for two main reasons: (1) the "lower" non-science track did not receive the attention and effort provided the "upper" science major track, and (2) the grade data analysis indicated the greatest difference in achievement was not the student's major but whether the student had taken chemistry in high school.

The decision was made to abandon the two-track system and replace it with a carefully combined course for all students taking General Chemistry. A chemistry tutorial center, open 20-30 hours per week for one-to-one tutoring and for the use of supplementary audio-tutorial materials, was established to maximize supplemental individualized instruction.

Students who had not had high school chemistry were required to take Introductory Chemistry before taking the first quarter of General Chemistry. Students who had a weak high school preparation in chemistry were identified by a placement examination and were advised, but not required, to take Introductory Chemistry. The introductory course was very well-received, but the teachers were still dissatisfied with the lack of individual contact resulting from large sections.

In addition, the admission of students who were less prepared than the average placed an even greater responsibility on the director and the chemistry faculty to provide high quality instruction.

Because of a limited number of available faculty members, some classes of 20 students or fewer were advisable but not practical. The faculty felt that even classes as small as 20 did not involve the student with the subject

to the degree necessary for mastery or operant forms of learning. Two alternative methods of instruction were considered: personalized systems of instruction (known as PSI or the Keller Plan) and audio-tutorial instruction. Audio-tutorial instruction was chosen principally for two reasons: (1) the professor maintains maximum control and direction over the course because he or she not only writes the objectives for the course but also translates them into the actual teaching tools used, e.g., study guides and audio tapes; and (2) the quality of the course is not dependent upon student managers or proctors, but student help can be used effectively in tutoring and in the physical operation of the learning center.

The Minicourse System

The most important facet of the course, however, is the use of minicourses within the overall course framework. The course is divided into 14 units which are called minicourses to indicate that each one is a definite learning entity. Each is designed to require no more than 2-3 hours of working time, but the student may spend more time if she or he wishes. Performance objectives and quiz retake options are used to encourage mastery learning, but there is a definite schedule which a student must follow -- one or two minicourses must be completed by Friday of each week. The student receives a course syllabus at the beginning of the quarter which contains the schedule for the entire course. The minicourses are self-pacing so that the student can attain mastery learning within the time-based restraint imposed by the printed schedule.

The minicourse system makes it possible for a student to skip over those topics which he or she has already mastered by use of prerequisite hierarchy associated with each minicourse. The specific topics covered in each minicourse are reflected in their titles, e.g., Chemical Elements and the Periodic

Chart, Naming Compounds and Writing Formulas, Balancing Chemical Equations, and Acids, Bases and Salts. At present, students are required to complete all 14 minicourses at a minimum average of 70 percent to receive a grade of C.

Format/Activities

The format of the minicourse, in the order which the student works through it, is a six-point outline consisting of: (1) summary of topics covered in the minicourse, (2) statement of the rationale for studying the minicourse, (3) listing of prerequisite minicourses, (4) instructional objectives stated in behavioral terms, (5) study guide containing textual material, illustrations, exercises and programmed instruction, and (6) posttest.

Each week during the quarter the student is engaged in four distinct activities: independent study, general class assembly, oral quizzing and written quizzing. In addition, the student may elect to retake either the oral or the written examination. Independent study refers to the time which the student uses to actually study the minicourse. The student proceeds to work through a minicourse by entering the chemistry tutorial center and removing his or her sign-in card from a card file. The date and time are recorded, the card is given to the tutor on duty and the student receives a copy of the audio cassette tape covering the minicourse being studied. Six copies of the tape for each minicourse have been more than sufficient to handle 40 students in a 50-hour week. Students pick their own study periods within the operating hours of the center.

Armed with the tape, the student picks up the desired minicourse booklet at the study carrel, puts on earphones attached to the cassette recorder and proceeds to work. Earphones and carrels permit several students to work in close proximity without distracting one another. A student survey during the

sixth week of the quarter revealed that 28 percent of the students had used the audio-tutorial tapes at home at least once. Nineteen percent studied from their own copy rather than from someone else's, and 14 percent studied the tapes at home on a regular basis. An honor system of tape distribution was quietly dropped after four tapes on one minicourse were taken (and not returned) over a two-day period.

Once each week the entire class meets in what is termed a general assembly during a regularly scheduled class period. At this time announcements of interest to the entire class, demonstrations of pertinent chemical phenomena are given and questions about subject matter and procedure are answered. Occasionally some of the period may be given to lecture, but in general this is avoided. It is envisioned that this session will always be conducted by a senior faculty member rather than by an instructor or graduate teaching fellow. When the audio-tutorial course was first instituted, general assembly sessions were held every other week, but it became readily apparent that the program proceeds more smoothly with weekly meetings. The absence of a roll call has not affected the attendance which has been very satisfactory.

Student Evaluation

Oral quiz sessions are held each week. The class is divided into sections of no more than 10 students each. Each quiz section meets for 30 minutes, seated around a table with questions directed to the students by the teacher in charge. If a student answers a question correctly, he or she is awarded seven points. If the student adds to another student's answer, he or she is awarded bonus points up to a total maximum of 10 points. In this way students are allowed to express their knowledge of the subject orally. Enthusiasm often runs high as students vie with one another for bonus points. Each student is told before

leaving the room how many points he or she has earned. Any student who does not attain the minimum seven points is given the option of a retake quiz after restudying the appropriate minicourses.

The entire class meets together for one-half hour each week to take a written quiz. The student is instructed to write his or her answers on the quiz sheet and on an answer sheet. When the student hands in the answer sheet, he or she is given a key, which is to be compared with the quiz sheet which the student has retained. On this basis the student makes his or her own decision whether or not to take the retake quiz. There has been some difficulty with students taking the retake without additional studying and doing as poorly the second time as the first, but that problem seems to lessen as the quarter progresses. There are 20 points possible on each weekly quiz. The student who retakes the written quiz is given the average of the original and retake scores. This is done to avoid procrastination in completing the required minicourses on schedule.

The questions in both the oral and written quizzes are based on the instructional objectives found in the appropriate minicourses. The style used is the same as that used in the minicourse posttest; so the student who has completed the posttest by mastering the objectives has a very good chance to do well on the written and oral quizzes.

The results to date have been gratifying. Because of the size of the oral quiz sections there is more teacher-student contact than is possible even in a conventional class of 20 students. This contact, in turn makes it possible for the teacher to have a clear understanding of each student's progress. Furthermore, it is one of the few methods applied to chemistry teaching where oral expression is encouraged and rewarded. Most important, perhaps, is the

fact that students are provided the means by which they can and must assume more responsibility for their learning than is true in a conventional class setting. However, teacher contact on a weekly basis insures that students who are not progressing as hoped for will receive counseling or help as needed.

EVALUATION OF THE PROGRAM

Although an analysis of all the data is yet to be completed, the deans, faculty and students who have participated in the program believe it has accomplished the major objectives. The freshman student is provided the opportunity to reinforce his chemistry background prior to taking General Chemistry; the program has reduced the percentage of failing grades in General Chemistry; the faculty have accepted the responsibility voluntarily and with enthusiasm; increasing numbers of freshman students in General Chemistry have utilized the services of the tutorial center; and the program has had a very favorable impact and influence upon other departments in the colleges and schools of the university.

Everyone at the university expects the program to continue and to become even more effective because of the receptive attitudes of both faculty and students. Expansion of the facilities of the tutorial center and the increase of more copies of the cassettes and visual aids used will enhance the services provided by the program.

Dr. Howell and Dr. Bedenbaugh will soon complete the development of a textbook to be accompanied by a programmed workbook specifically for Chemistry 100. A contract has already been negotiated with a major publishing company.

Student reactions to the program varied but all were positive. As one student responded, "It (the program) is like taking medicine; you don't like it

but you want to get well." The need for larger facilities and more duplicate copies of materials were mentioned by the seven students interviewed. The faculty who worked with the students in the tutorial center were credited for the effectiveness and success of the program.

Dr. Gary Wildman, dean of the College of Science and Technology, believes the program has been very beneficial and provides an opportunity for a large number of students who enroll in the university despite the inadequacies in their high school preparation. The majority of the students in the program have the aptitude and intellect required but simply have not had sufficient high school courses in either mathematics or science.

As for the future of the program, Dr. Wildman expects it to continue as long as the need is present. Until the high schools from which most of the university's students come provide and require specific courses for the graduation of college-bound students, Dr. Wildman does not believe the university has any choice.

Acknowledgments

Our sincere thanks and appreciation are extended to the following persons at the University of Southern Mississippi who very generously gave their time, assistance, and cooperation to make this report possible.

Dr. Aubrey K. Lucas, President

Dr. J. Emory Howell, Director of General Chemistry

Dr. John H. Bedenbaugh, Chairman, Department of Chemistry

Dr. Gary Wildman, Dean, College of Science and Technology

Dr. Stephen A. Dablin, Professor of Mathematics

Ted Elchos, Gail Kennedy, Sharon Laurendine, Marcia Mayfield, Maxie Medders, Paulette Miller and James Sheffield who are students in the university.